

2018 FAYETTEVILLE CLIMATE RESILIENCE ASSESSMENT



UNIVERSITY OF
ARKANSAS
Office for Sustainability



CITY OF
FAYETTEVILLE
ARKANSAS



EXECUTIVE SUMMARY

For the first time, the University of Arkansas and City of Fayetteville collaborated to develop a Climate Resilience Assessment, which aimed to identify Northwest Arkansas' vulnerabilities, strengths, and areas for improvement in terms of sustainability and community resilience. Led by the University of Arkansas Office for Sustainability and the City of Fayetteville Sustainability Department, there were five key stakeholder meetings in the fall of 2017 to start a conversation about climate change and the associated implications for Fayetteville, Arkansas.

The resilience assessment analyzed Fayetteville's strengths and vulnerabilities across five domains of climate resilience. These domains must be considered as assets to create a truly resilient community: social, health, natural, physical, and economic. These five domains, individually observed for the sake of analysis, are interconnected and interdependent. All five must be considered and addressed to ensure for the development of a resilient city. Each stakeholder meeting focused on individual domains, which consisted of an introduction to the topic of resilience and sustainability, a description of three extreme climate scenarios that the City of Fayetteville may face, and the resilience assessment. The resilience assessment portion of the meetings tasked the key stakeholders with identifying current resiliency strengths and vulnerabilities, and then prioritized each based on their significance. Next, the stakeholders identified the most notable vulnerabilities to their specific domain. After the Climate Resilience Assessment was complete, the stakeholders brainstormed opportunities to address challenges specific to their domain. Once the stakeholder meetings were finished, a nine question survey was completed by the campus, city, and community members invited to the stakeholder meetings. The purpose of the survey was to have key stakeholders prioritize strategies that could be taken to promote community resilience.

Perhaps the most significant outcome of performing this climate resilience assessment was initiating the conversation regarding community resilience within Fayetteville. While efforts that support resilience and sustainability did exist within the community prior to this assessment, these initiatives were often independent and without an understanding of their role in promoting community resilience. This assessment allowed the facilitators of these initiatives, along with other key stakeholders within the community, to have a focused community resilience conversation. These meetings emphasized how the efforts of each stakeholder, and the groups they represented, are cogs in a larger resilience machine that will be used to minimize the effects of climate change.

The meetings identified three climate eventualities-extreme heat, drought, and rainfall—for which the stakeholders sought to establish possible affirmative strategies for. Overall, this assessment established a network of key community stakeholders working together to strengthen the resilience of our community in the face of a changing world. Ultimately, the assessment led to the creation of a Climate Resilience Assessment, which details both the challenges our community is likely to face as well as strategies to mitigate these challenges.

INTRODUCTION

Community resilience is the a community's ability to anticipate, adapt, and flourish in the face of change. The changing climate is predicted to cause unusual and harsh weather conditions worldwide, including in Fayetteville, AR. If not addressed, these future events will have detrimental impacts on the city and those who call it home. To best assess the strengths, vulnerabilities, and future opportunities necessary for resiliency, the University of Arkansas' Office for Sustainability (OFS) led a collaboration between the City of Fayetteville (CoF) and the University of Arkansas (UA) to develop a Community Resiliency Assessment.

There are five domains of climate resilience which must be considered as assets to create a truly resilient community: social, health, natural, physical, and economic. The social domain involves community identity and engagement, including elements such as participation in community events, inclusivity, and community connectivity. The health domain encompasses health and wellness, and includes hospitalization numbers and overall quality of life. The natural domain focuses on the natural environment, including biodiversity, ecosystem health, and green spaces. The physical domain involves infrastructure and energy, and includes storm water management, grid load and transportation access. The economic domain encompasses all things money, including tourism, wage-of-living and local business health. These five domains, while made distinct for the sake of analysis, are interconnected and interdependent. As such, all five must be considered and addressed for the development of a resilient city.

5 DOMAINS



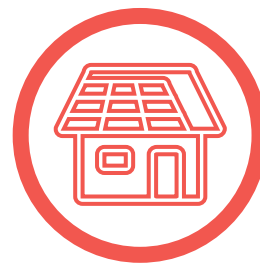
SOCIAL



HEALTH



NATURAL



PHYSICAL



ECONOMIC

It is important to note that a resilience assessment and development of a City Resiliency Plan is just the beginning. Strategies are nothing without the actions that follow. Resiliency deals with adapting to change, and, as such, it is an uncertain practice. One of the key components of resiliency is adaptability, and this includes the continued improvement of the resilience plan. To be resilient, a community must dedicate itself to continual assessment and innovation. Future resiliency assessments will need to be performed at set intervals and the City Resilience Plan adjusted accordingly.

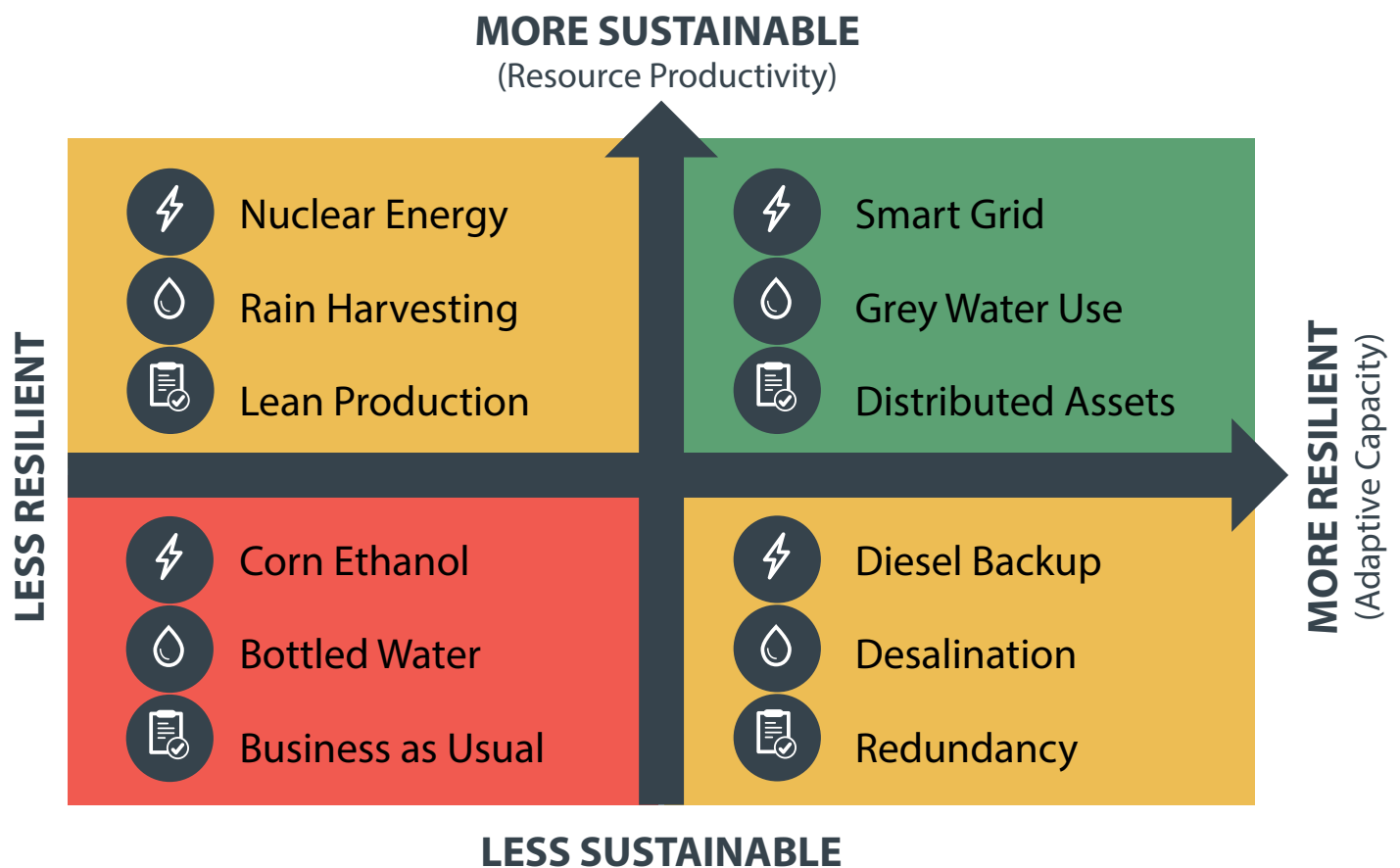
In performing this initial assessment, the hope is to inspire a culture of resilient thinking within Fayetteville, starting with the key stakeholders and through them, permeating the broader community. The goal is to start conversations that will allow the community to identify more key stakeholders, and move towards taking action.

SUSTAINABILITY VS RESILIENCE

A preliminary step in building a culture of resiliency and a more climate-ready community is to establish the commonalities and differences between sustainable and resilient development. Sustainability and resilience are complementary concepts, but they do have some key differences.

Sustainable development is most commonly defined as development that meets the needs of the present without compromising the ability for future generations to meet their own needs, according to the UN World Commission on Environment and Development.¹ The National Environmental Policy Act of 1969 states that the purpose of sustainability is “to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations.”²

Meanwhile, resilience is the ability of a system or community to anticipate, adapt, and flourish in the face of change. Resilience applies to both recovering from short term disruptions and adapting to long-term trends. It is imperative that Fayetteville develops and deploys strategies that have a minimal environmental impact while also being adaptable enough to thrive in a continually changing climate.



¹ World Commission on Environment and Development. (1987). *Our Common Future*. Retrieved from: <http://www.un-documents.net/our-common-future.pdf>

² The National Environmental Policy Act. (1969). Retrieved from: https://www.whitehouse.gov/sites/whitehouse.gov/files/ceq/NEPA_full_text.pdf

REGIONAL CHARACTERISTICS

The City of Fayetteville is located in the Northwest corner of Arkansas and prides itself on being a cultural, academic, economic, and natural hotspot of the state. Nestled in the Ozark Mountains and home to the University of Arkansas, Fayetteville's landscape is comprised of temperate forests, hilly topography, and perennial streams. Fayetteville draws tourists of many kinds, whether they come to cheer on the Razorbacks at an athletic event, to hike on one of the hundreds of miles of nature trails in the area, or to attend one of the frequent cultural events. Residents like to characterize their city and community as inclusive, naturally beautiful, vibrant, progressive, and sustainable.

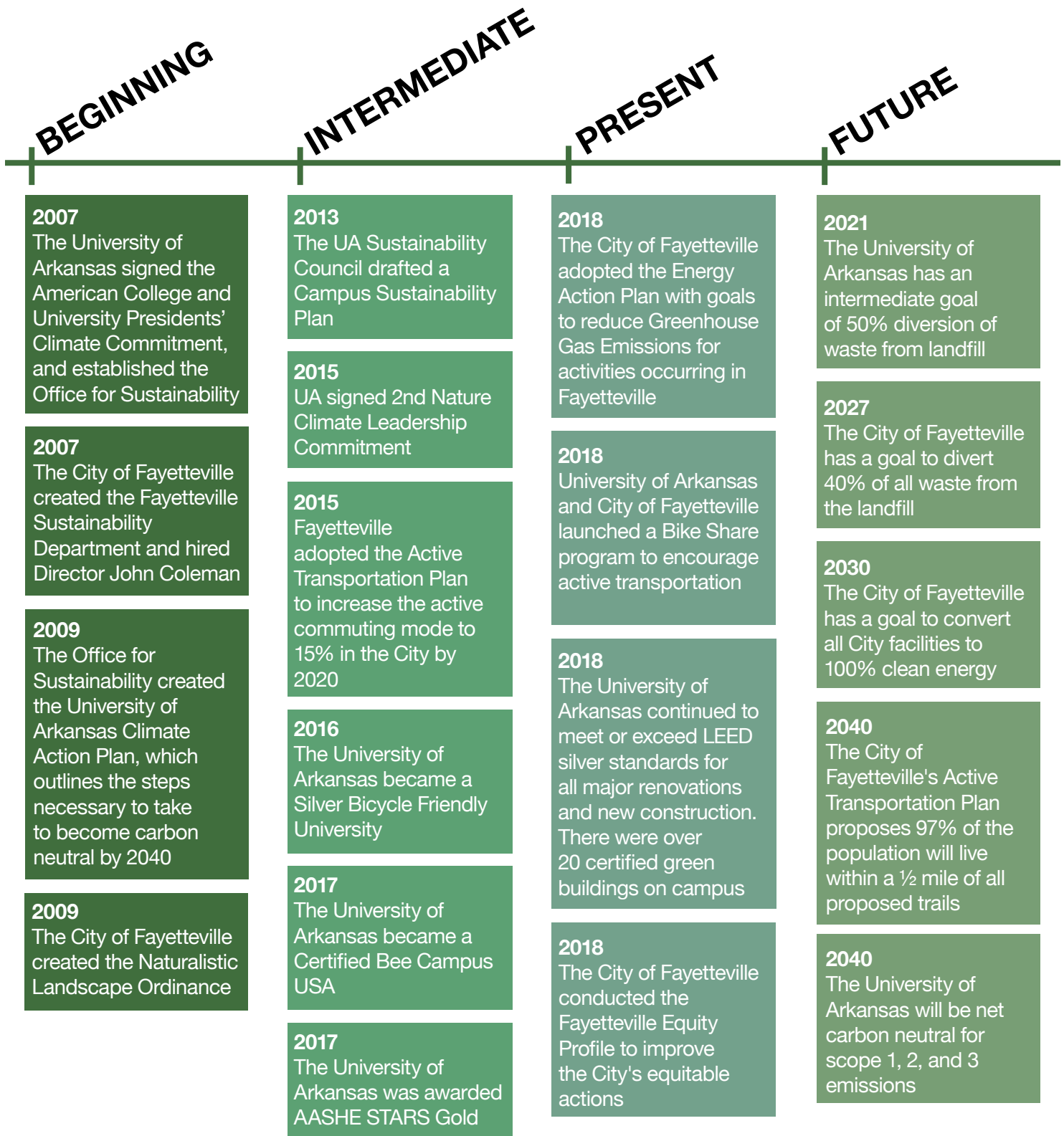


Fayetteville is thriving, ranking within the USA Top Five Best Places to Live by U.S. News & World Report for the third year in a row.³ Mayor Lioneld Jordan responded to the award in a news release stating, “Our region is attractive for its career opportunities, thriving outdoor culture, strong education system, cultural arts, diversity, and general quality of life. We’re continually working with partners to make Fayetteville a desirable place for people to live, work, learn, visit, and play.”

However, the continued prosperity of Fayetteville is not guaranteed. Anthropogenic climate change poses short and long-term dangers to the community that, if ignored, could drastically change the quality of life in Fayetteville and its surrounding areas. Before considering the vulnerabilities and strengths of the region, it is important to review the past and present climate characteristics.

³ U.S. News and World Report. (2018). 125 Best Places to Live in the USA. Retrieved from: <https://realestate.usnews.com/places/rankings/best-places-to-live>

COMMUNITY RESILIENCE TIMELINE



METHODS

There were five meetings with attendees from the University of Arkansas, the City of Fayetteville, and community organizations to determine the topics of priority within the five domains of resilience. Each meeting had different expert attendees and focused on one domain. The attendees represented a diverse group selected by their peers. For example, the Ecosystem Vitality stakeholder meeting consisted of community attendees from the Beaver Watershed Alliance, Northwest Arkansas Land Trust, Watershed Conservation Resource Center, Sustainability Consortium, CoF, and UA. The Physical/Infrastructure meeting included representatives from SWEPCO, Ozarks Electric, and a wide array of individuals from UA and CoF departments. The Human Health stakeholders incorporated members of University Recreation, the CoF fire department, and the Arkansas Department of Health along with others. The Economic resilience stakeholder meeting brought together community members from Start Up Junkie Consulting, the CEA of Agriculture at the Washington County Extension Service, the Economic Vitality Director of the City of Fayetteville, and other engaged parties.

Appendix B Tables 3-7 contain a complete list of attendees, however that list does not represent all of those invited. For each individual stakeholder meeting, approximately 20 university, city, and community members were invited to discuss resiliency strategies. Meeting locations, dates, and number of attendees for each domain's stakeholder meeting are shown in Table 2 of Appendix B.

The five stakeholder meetings consisted of a brief presentation defining resiliency and sustainability, then briefed attendees on objectives, outcomes, and assessment strategy. Stakeholders worked in three groups to assess strengths and vulnerabilities of the City of Fayetteville if the area was to experience each of the three extreme climate scenarios, which outline common climate vulnerabilities and risks. The scenarios discussed were extreme heat, drought, and heavy precipitation or flooding. These scenarios are based on actual historic extreme climate data for Fayetteville, AR from 1892 to present (Table 1 in Appendix A).

Participants in each of the three groups discussed the strengths and vulnerabilities of Fayetteville in relation to their climate scenario. A matrix was developed based upon each group's discussion. The meeting attendees brainstormed the strengths and weaknesses of the community within the meeting's domain. These strengths and weaknesses are tabulated in Tables 8-10, with recurring items noted for further discussion. In all five meetings, the discussion was lively and the representatives converged on some priority issues.



EXTREME WEATHER SCENARIOS

1. HEAT STRESS

"After a normal spring, Fayetteville starts the summer warmer than usual with an average daytime high temperature during the month of June of 93 degrees and 4 days where the temperature topped 100 degrees. In July, the average high was 99 degrees, with 18 days where the temperature topped 100 degrees. The first 8 days of August all topped 105 degrees, with August 3rd tying the all-time record high in Fayetteville of 111 degrees. The city has only received 2 inches of rain before June 1st and the forecast for the remainder of August is for continued hot/dry conditions."

The key stakeholders envisioned a Fayetteville where most people stayed inside and used copious amounts of power to air condition their homes. This also had vast social aspects on our community as many cultural aspects, such as our farmer's market, hiking trails, and outdoor events, were abandoned by the population as most people stayed inside. Development activity in the community decreased, because it would be too hot to work outside. Tick and mosquito populations were much larger than usual. Urban heat island effect would be enhanced by uncontrolled sprawl. At-risk populations, such as the homeless and low-income, suffered from heat-related illnesses to a high degree. Non-heat resistant trees died off, worsening heat island effect and marring Fayetteville's identity as a Tree City. Fossil fuel use increased from need for AC and from increased car transportation over walking or biking. Additionally, tourism in Fayetteville dwindled as most of the elements that draw visitors, the Farmer's Market, natural spaces, athletic events, and cultural events became too hot to enjoy.

2. DROUGHT STRESS

"Following an unusually dry winter and spring (only 9 inches of rainfall since January 1st), Fayetteville starts the first week of July with a long-range forecast for hot/dry conditions all month. Local creeks and rivers are either bone dry or have just a trickle of water flowing in them. Beaver Reservoir is at its lowest water level in 35 years with a forecast for record high summer water demand due to lack of rainfall and dry soil conditions. The US Drought Mitigation Center rates the region in Exceptional Drought (D4) with precipitation totals among the lowest 2 percent on record in a broad area of the Ozark/Boston Mountains."

The key stakeholders envisioned a Fayetteville where drought had dropped the water level of Beaver Lake to an all-time low. This would prove especially problematic since NWA had no established plan on how to share water rations. Arguments among the different cities of NWA caused high levels of stress between populations. Limited water supplies also led to increases in water and food prices and low-income populations began to struggle to meet their diminishing while the spending power of much of the local population became diminished. This negatively impacted the local economy, as people had less money to spend at local businesses. The ecology of the city also struggled, as the drought caused much of the flora to suffer. Urban sprawl had fragmented the natural spaces, making the ecology less resilient and causing the populations of many local species to struggle, especially in riparian zones. Tree species not resistant to heat and drought died off, increasing the heat island effect and making urban areas hotter than before. Overall, Fayetteville's flora became dry and shriveled, putting the city at ever increasing risk of fire.

3. HEAVY PRECIPITATION AND FLOODING

"After an unusually warm and wet late fall with 9 inches of rain in November and 12 inches of rain during the last 8 days of December, Fayetteville starts the New Year soggy and wet with all the local reservoirs at flood stage. Warmer than normal fall temperatures have also resulted in Gulf of Mexico water temperatures that are 10 degrees warmer than normal. On January 3rd a warm front from the Gulf begins pumping moisture into the Ozarks region with an additional 14 inches of rain falling in Fayetteville over a 24-hour period. Already swollen streams are pushed beyond previously recorded flood levels with several stream gages completely washed away by the epic flooding. The long-range forecast for January and February is for continued warm/moist conditions."

The key stakeholders envisioned a Fayetteville that had experienced unprecedented flooding. Important infrastructure, such as roads and bridges, are underwater or even destroyed. This has caused disruptions in the supply chain through and around Fayetteville, hurting local economy and skewing supply and demand. This has also caused a disconnect between many parts of the city where transportation routes have been closed or blocked. Daily life, including government jobs and college classes, have been interrupted due to the treacherous conditions. Flooding has damaged stream banks, in some cases completely washing away previously established banks. The continual saturation of the land has also led to landslides. Streamside and lowland properties have been flooded, causing massive damage to residential and commercial buildings. This has led to a significant portion of the population in need of housing and care. Concerns have been raised about possible contamination of the drinking water as Beaver Lake swells larger than ever with runoff from surrounding areas.



Photo courtesy of Adam Putman

RESULTS FROM STAKEHOLDER MEETINGS

VULNERABILITIES

The discussion within the stakeholder meetings identified the following points as vulnerabilities within Fayetteville if no actions were taken to bolster city resilience. These vulnerabilities were drawn upon to construct narratives of what Fayetteville would resemble in the face of Extreme Heat, Drought, or Extreme Precipitation. Table 8 lists the vulnerabilities of each domain.

Table 8: Vulnerabilities of the Five Domains of Climate Resilience Due to the Extreme Climate Scenarios

	HEAT	DROUGHT	EXTREME PRECIPITATION
ECONOMIC	<ul style="list-style-type: none"> -Reduced tourism -Spending on AC spike -Outdoor jobs slow/decline 	<ul style="list-style-type: none"> -Food/water expense increase -Less disposable income 	<ul style="list-style-type: none"> -Supply-chain disruption -Property damage -Land loss
NATURAL	<ul style="list-style-type: none"> -Beaver Lake water quality/supply flux -Tree stress -Biodiversity decrease 	<ul style="list-style-type: none"> -Beaver Lake water quality/supply flux -Riparian system stress -Tree stress 	<ul style="list-style-type: none"> -Stream bank erosion -Damage to riparian zones -Landslides
PHYSICAL	<ul style="list-style-type: none"> -Fragmenting of natural areas due to sprawl -Non-redundant water network -Power grid stress 	<ul style="list-style-type: none"> -Fragmenting of natural areas due to sprawl -No established plan for sharing Beaver water supply with NWA 	<ul style="list-style-type: none"> -Infrastructure failure -Property damage -Debris -Sedimentation
HEALTH	<ul style="list-style-type: none"> -Heat-related illness -Wildfire risk -Insect-related disease 	<ul style="list-style-type: none"> -Less access to food/water -Wildfire risk 	<ul style="list-style-type: none"> -Flooding -Drinking water contamination
SOCIAL	<ul style="list-style-type: none"> -Outdoor culture at risk -Less community engagement -Communication barriers 	<ul style="list-style-type: none"> -Low-income populations at greater risk -Communication barriers 	<ul style="list-style-type: none"> -Disruption in social services -Displaced populations -Communication barriers

After the five stakeholder meetings, the list of vulnerabilities from each was compiled into Table 9, which outlines the most significant vulnerabilities, and how many times they were mentioned throughout the resilience assessment. This assessment allows the University of Arkansas, the City of Fayetteville, and community members to better interpret what our most serious vulnerabilities are associated with, and the frequency in which they occur.

Table 9: Recurring Vulnerabilities Discussed at Stakeholder Meetings

VULNERABILITIES	ECOSYSTEM	INFRASTRUCTURE	ECONOMIC	SOCIAL	HEALTH	COUNT
Tourism & recreation impacts	X	X	X	X	X	5
Water infrastructure damage potential	X	X	X		X	4
Water- water supply water quality, single source (Beaver Lake)	X	X		X	X	4
Lack of regional approach (with respect to Beaver Lake water allocation)	X	X	X			3
Political climate	X		X	X		3
Lack of water conservation	X	X		X		3
Electrical distribution		X	X	X		3
Ground – soil shrinkage and swelling causing increased runoff, damage to infrastructure, and erosion	X	X	X			3
Property damage due to fire and flood		X	X		X	3
Shelter locations/ capacity, access to food and health care		X		X	X	3
Development trends and rate of development	X		X			2
Reservoir structures and systems	X	X				2
Food production (chickens, fruits, and veggies)			X		X	2
Transportation for affected populations to medical services and/ or shelters/centers				X	X	2

STRENGTHS

The key stakeholders identified strengths of the CoF that make the city more resilient to the three extreme climate scenarios, as shown below in Table 10. After outlining the strengths of each domain of climate resilience, strengths were grouped into the Four Major Strengths of the area, determined by the frequency in which the strength was listed by the stakeholders. These Major Strengths were identified as Fayetteville's Natural Areas, Topography, Community, and Beaver Lake.

Table 10: Strengths of the Five Domains of Climate Resilience Due to the Extreme Climate Scenarios

	HEAT	DROUGHT	EXTREME PRECIPITATION
ECONOMIC	<ul style="list-style-type: none"> -Fayetteville's economy does not rely on agriculture -UA isn't water dependent -Affordable water -Our ecosystem can be fire resistant 	<ul style="list-style-type: none"> -Reliable water source -UA student population not active -New building stock with AC -Low utility cost 	<ul style="list-style-type: none"> -Topography -Road network -Communication and collaboration -Emergency Management Plan -LID Drainage Criteria Manual
NATURAL	<ul style="list-style-type: none"> -Tree canopy provides shading and soil protection -Trail corridors -General love of outdoors 	<ul style="list-style-type: none"> -Diverse landforms -Micro-climates -Diverse forest composition -Groundwater resources 	<ul style="list-style-type: none"> -Topography -Tree canopy coverage -Plans to increase reservoir capacity -Knowledge base and expertise to improve stream corridor
PHYSICAL	<ul style="list-style-type: none"> -Prevalence of AC spaces -Increasing efficiencies as technology advances -UA co-generation steam plant -AR Net Metering Laws -Native vegetation -Green spaces 	<ul style="list-style-type: none"> -Abundant water supply -CoF water rationing ordinance -Additional area lakes -Native vegetation reduces irrigation requirements 	<ul style="list-style-type: none"> -Topography -Detention policy in CoF Development Code -Road network for emergency access -Electrical transmission system
HEALTH	<ul style="list-style-type: none"> -Lots of healthy young people -Trees/streams -Existing cooling center strategy FBoH -AC common in buildings 	<ul style="list-style-type: none"> -Infrastructure -Communication -Good relationships across departments 	<ul style="list-style-type: none"> -Ability to provide clean water -Topography -USGS stream gauges
SOCIAL	<ul style="list-style-type: none"> -Resilience conversations -Groups/organizations can quickly mobilize -Human/intellectual capital 	<ul style="list-style-type: none"> -Drought ordinance -Acceptance of LID and native landscapes -Conservation ethos -Turf intramural fields -Residential awareness 	<ul style="list-style-type: none"> -Emergency notification -Town and Gown Community philanthropic and non-profit support



NATURAL AREAS

The “Natural Areas” of Fayetteville are defined as including the Enduring Green Network (EGN), a network of connected green spaces that runs throughout Fayetteville, local natural parks, and the well-developed and protected tree canopy present in most of our urban spaces. These Natural Areas provide extensive ecosystem services that promote the resiliency of Fayetteville. The vegetated areas of our city are vital to slowing, capturing, and cleaning storm water, reducing the effects of flooding, and bolstering the effectiveness of our infrastructure. The tree canopy minimizes the urban heat island effect. Having connected green spaces, like in the EGN, also helps preserve biodiversity, as the fauna have room to roam even in harsh conditions. Finally, our Natural Areas have huge economic importance as a draw for tourism, and huge social importance as part of Fayetteville’s cultural identity.

TOPOGRAPHY

Situated in the Ozark Mountains, Fayetteville boasts a diverse topography of hills, valleys, streams, fields, and forests. This topography provides many strengths including reducing the areas in danger of extreme flooding since most of the city is built on a slope. Bodies of water such as creeks and streams provide natural cooling, helping reduce the effects of extreme heat. The diverse topography also lends itself to a varied natural biodiversity, with flora and fauna naturally resilient to changes in temperature and environment.

COMMUNITY

Fayetteville has a community-focused atmosphere and a long-standing culture of respect and appreciation for nature. Fayetteville is also home to the University of Arkansas, a Tier I Research University that attracts students and faculty from all over the world. This has resulted in a culture that promotes environmental stewardship, innovation, and social inclusion. Fayetteville prides itself on being a leader in Arkansas and the USA in sustainable action. It is likely that this population will similarly embrace the idea of resilience and support the adoption of resilient policy within the city.

Fayetteville's relationship with the University of Arkansas presents several other unique strengths. The University provides a pool of experts in nearly every field that can research or provide solutions to even the most complicated and difficult resilience issues. The student body also creates an opportunity for collaborative projects. Lastly, the University shifts Fayetteville's demographics towards young and healthy people who are much less likely to fall ill due to any of the three scenarios than other age groups.

BEAVER LAKE

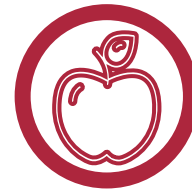
Beaver Lake provides drinking water to all Northwest Arkansas. It is a plentiful supply of water, with even the worst predictions showing Beaver as being able to meet the basic needs of Northwest Arkansas. This means that in any of the three scenarios, Fayetteville’s population should still have access to clean, fresh water. However, Beaver Lake may become low enough to trigger water rationing. The biggest challenge to Beaver lake is that it's a shared resources between the Northwest Arkansas communities, which could create conflict in times of severe drought.

SURVEY RESULTS

A survey was developed to select what the key stakeholders viewed as the most significant actions that could be taken to promote community resilience. Each question considers the five domains, and touches on topics such as water, land, agriculture, and infrastructure. The stakeholders answered questions by evaluating the potential strategies for each scenario quantitatively on a 1 to 5 scale, the lowest level of protection each action would provide being a 1, and the highest level of protection being a 5. A weighted average was determined for each strategy. Figures 1-9 show the results from each survey question, where the answer choices are given in order of highest weighted average. The strategies for each topic were developed by Fayetteville and the University of Arkansas, with aims to provide the stakeholders with solutions to impending issues Northwest Arkansas communities may have to overcome. The survey was sent to all of the campus, city, and community members who were invited to stakeholder meetings.



WATER SUPPLY



QUESTION 1:

While stakeholders identified Beaver Reservoir as an invaluable resource and abundant water supply for Northwest Arkansas, they also noted that as our sole drinking water source, Beaver Reservoir poses potential risks from a water quality and water quantity perspective. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting the water supply of Northwest Arkansas.



Weighted Average of Strategies for the Greatest Water Supply Protection

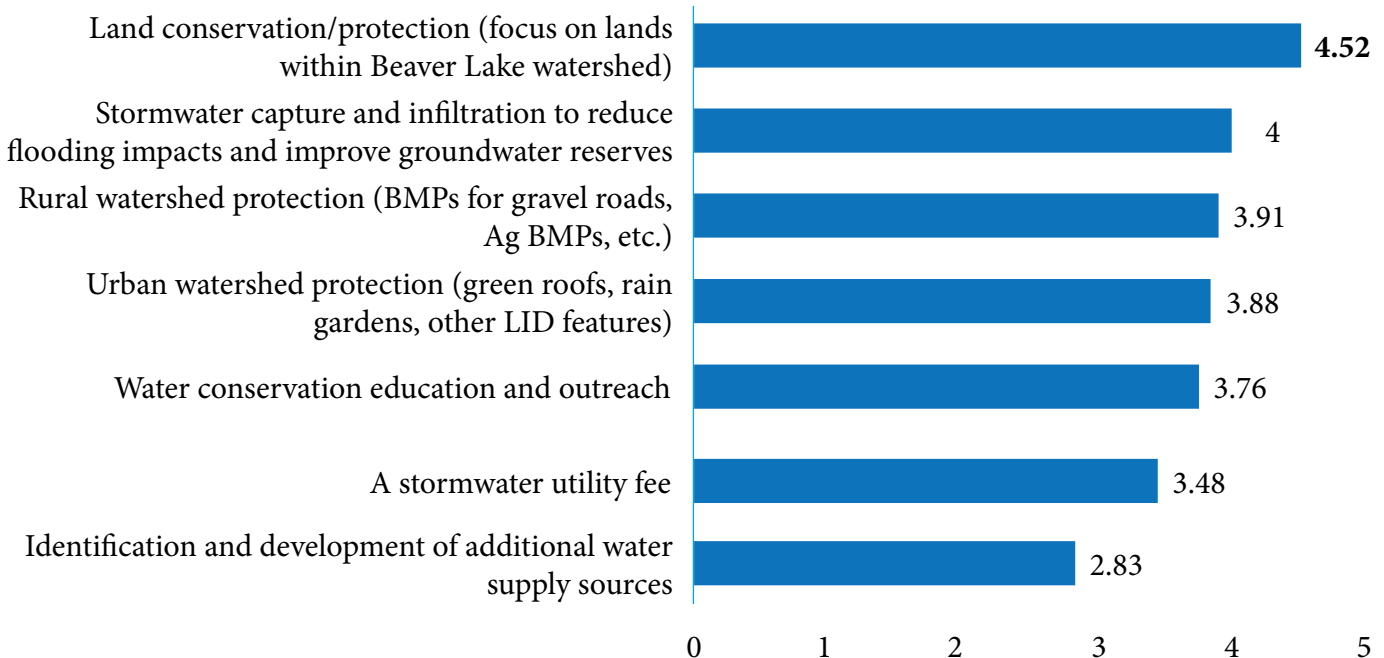
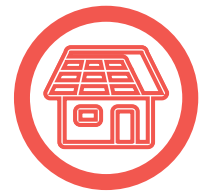


Figure 1: Results for the Strategies needed to achieve Water Supply Protection

RAPID LAND DEVELOPMENT



QUESTION 2:

While stakeholders identified growth in Northwest Arkansas as a source of economic benefit, they also identified rapid and unsustainable land development as a threat to ecosystem health, urban forests, and water quality. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting ecosystem health, urban forests, and water quality in Northwest Arkansas.



Weighted Average of Strategies for the Greatest Land Development Protection

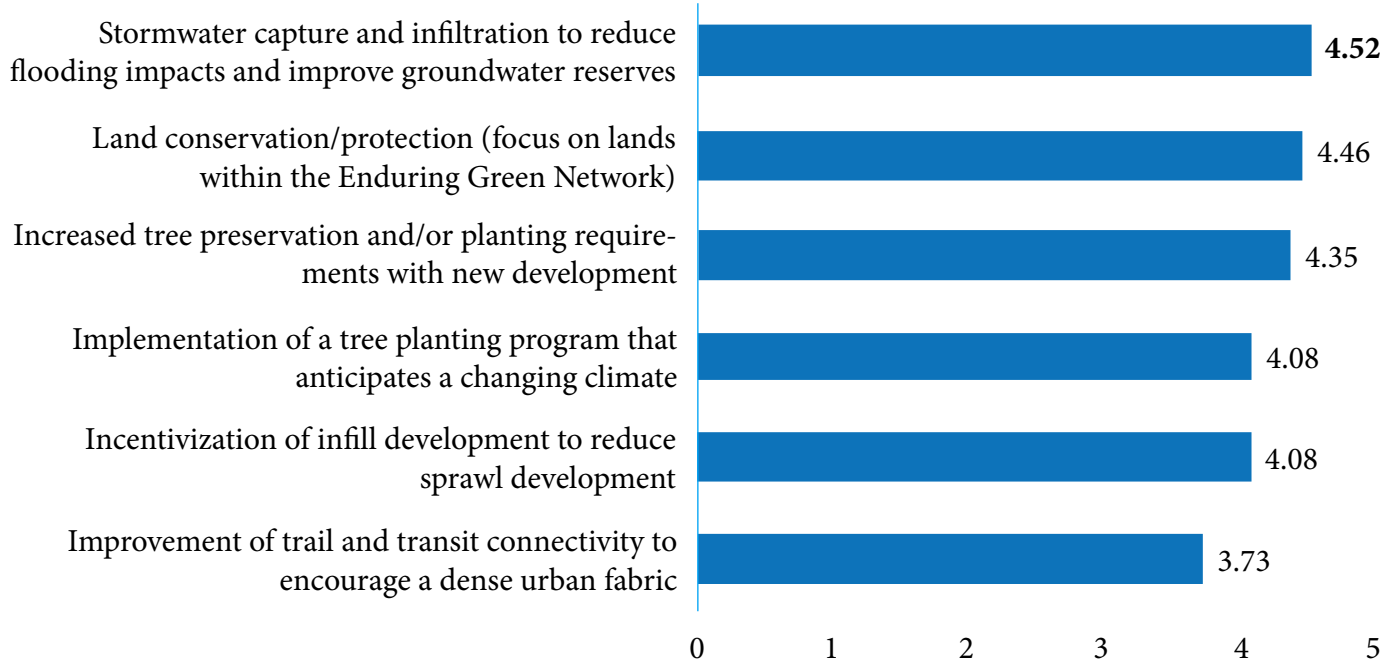
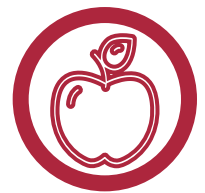


Figure 2: Results for the Strategies needed to achieve Land Development Protection

AGRICULTURE & FOOD PRODUCTION



QUESTION 3:

While stakeholders identified agriculture and food production as an important component of the economy in Northwest Arkansas, they also recognized vulnerabilities in those systems, particularly related to heat and drought stress. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting food systems.



Weighted Average of Strategies for the Greatest Agriculture and Food Protection

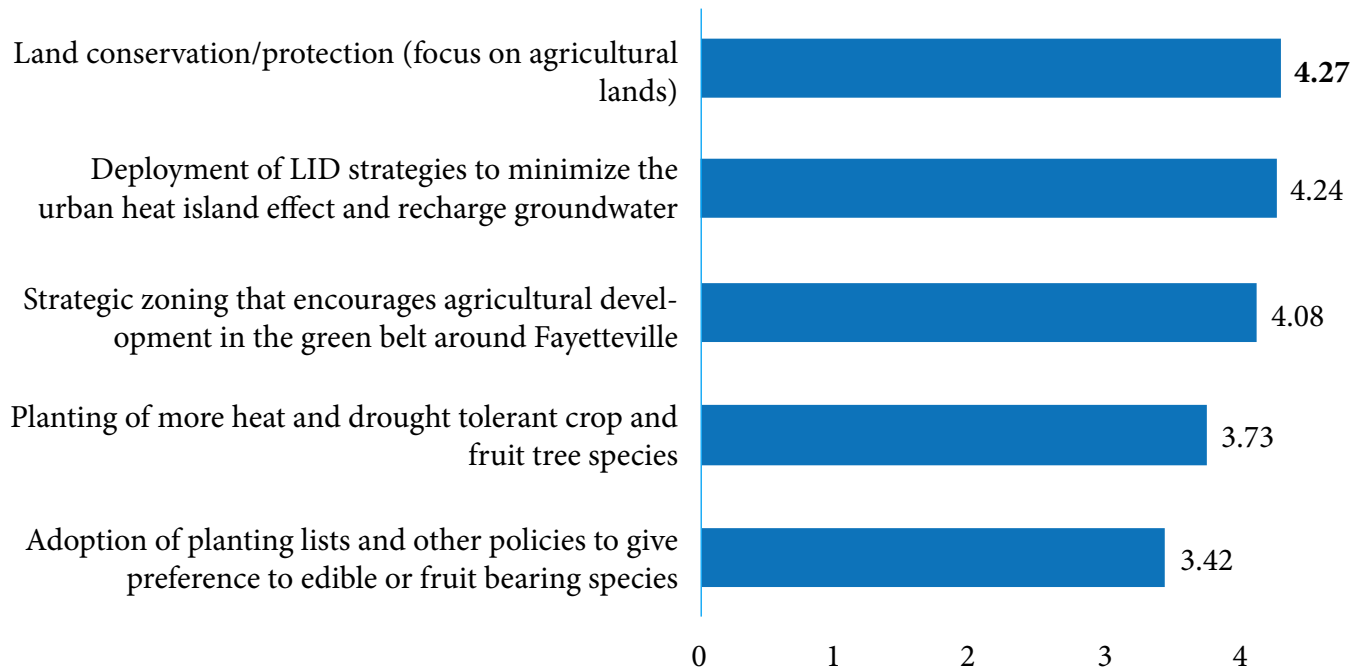
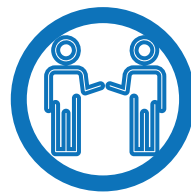


Figure 3: Results for the Strategies needed to achieve Agriculture and Food Protection

AT-RISK POPULATIONS



QUESTION 4:

Resilience stakeholders identified marginalized and at-risk populations (primarily low income and homeless) as being particularly vulnerable to heat, drought stress, and extreme flooding in Northwest Arkansas. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting at-risk populations.



Weighted Average of Strategies for the Greatest At-Risk Populations Protection

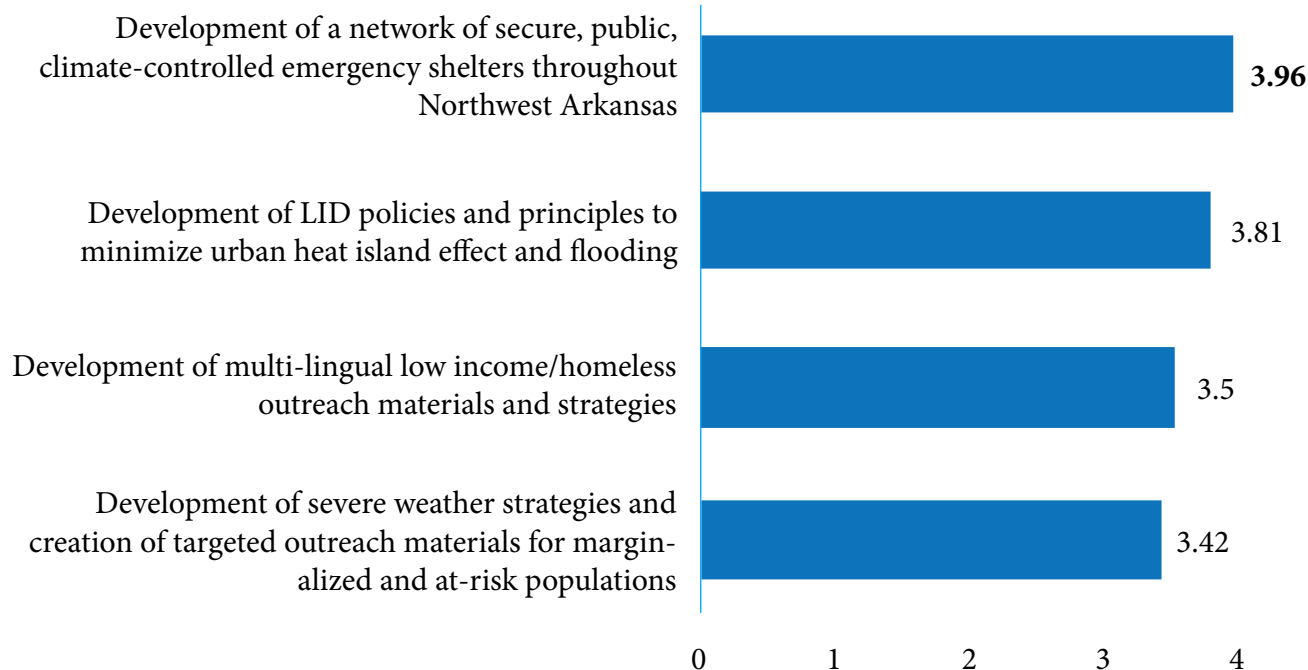


Figure 4: Results for the Strategies needed to achieve At-Risk Populations Protection

NATURAL HABITAT & SPECIES LOSS



QUESTION 5:

While stakeholders identified Northwest Arkansas' natural beauty and open spaces as beneficial amenities, they also identified the loss of natural habitat & species as a major threat to these resources. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting the natural habitat and species diversity in Northwest Arkansas.



Weighted Average of Strategies for the Greatest Natural Habitat and Species Loss Protection

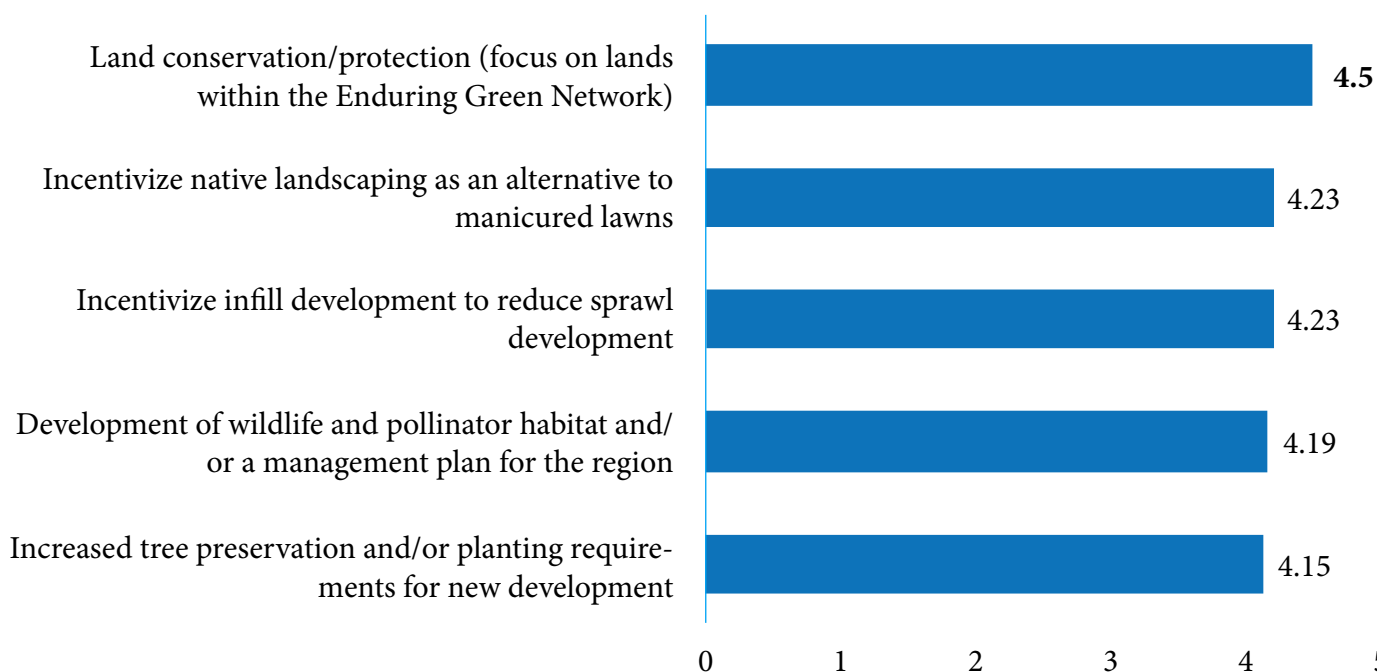


Figure 5: Results for the Strategies needed to achieve Natural Habitat and Species Loss Protection

WILDFIRES



QUESTION 6:

Resilience stakeholders identified lands along the urban/wildland interface as being particularly vulnerable to wildfires during times of drought stress in Northwest Arkansas. Please rate these strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on preventing wildfires.



Weighted Average of Strategies for the Greatest Wildfire Protection

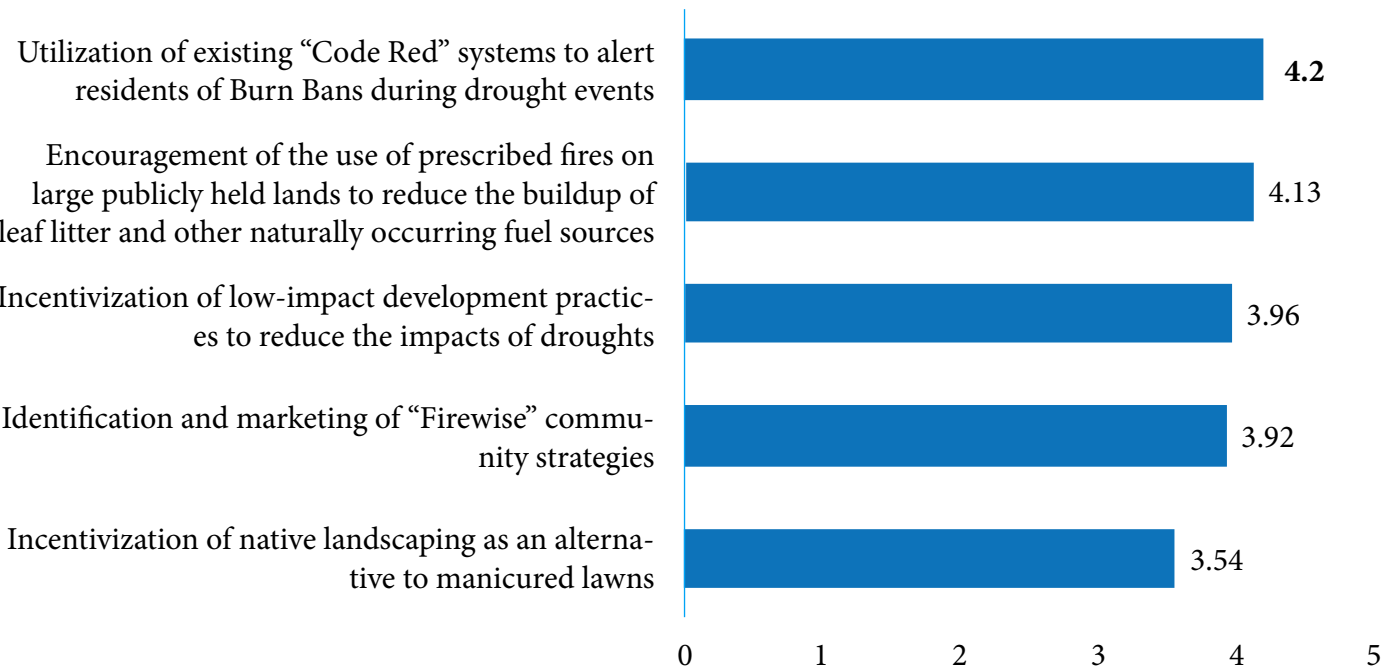


Figure 6: Results for the Strategies needed to achieve Wildfire Protection

ELECTRICAL DISTRIBUTION



QUESTION 7:

Resilience stakeholders identified the electrical distribution system as being particularly vulnerable to failures during times of heat stress and high electrical demand in Northwest Arkansas. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on reducing demand on the electrical distribution system and preventing system failures.



Weighted Average of Strategies for the Greatest Electrical Distribution Protection

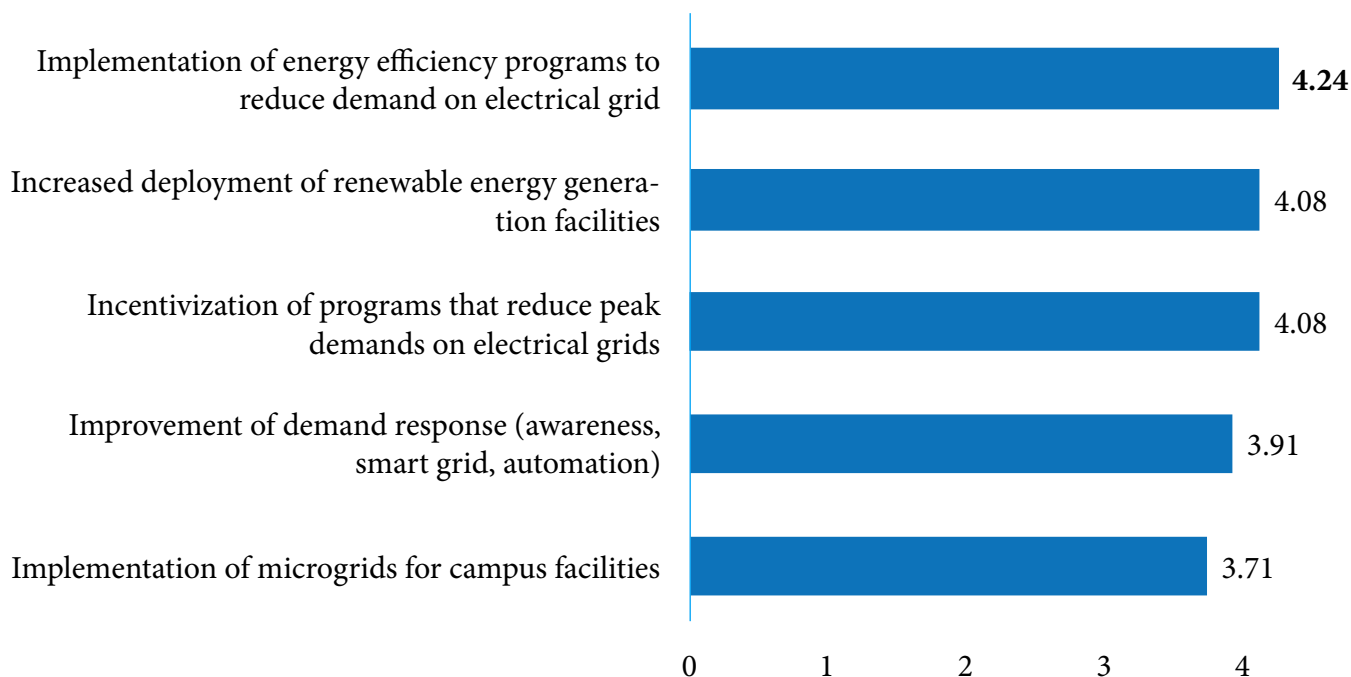


Figure 7: Results for the Strategies needed to achieve Electrical Distribution Protection

INFRA- STRUCTURE



QUESTION 8:

Resilience stakeholders identified the city sewage infrastructure and transportation system infrastructure as being particularly vulnerable to flooding from heavy precipitation events in Northwest Arkansas. Please rate the following strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on protecting infrastructure from failures during flooding.



Weighted Average of Strategies for the Greatest Infrastructure Protection

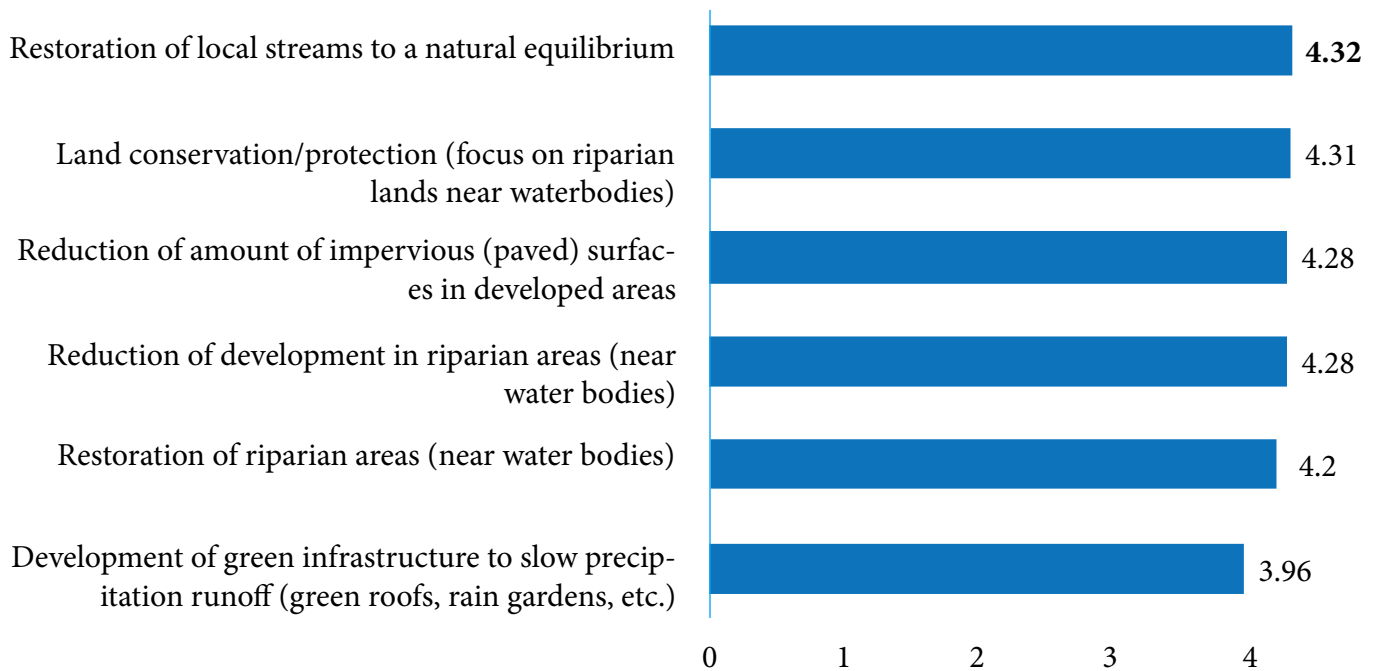


Figure 8: Results for the Strategies needed to achieve Infrastructure Protection

RECREATION & TOURISM



QUESTION 9:

While Resilience stakeholders identified recreation and tourism as growing segments of the Northwest Arkansas economy, they also recognized heat and drought stress as threats to that economic growth, particularly during the summer months. Please rate these strategies from 1 to 5 (1 = lowest level of protection and 5 = greatest level of protection) in terms of their impact on decreasing heat/drought stress on summertime recreation/tourism.



Weighted Average of Strategies for the Greatest Recreation and Tourism Protection

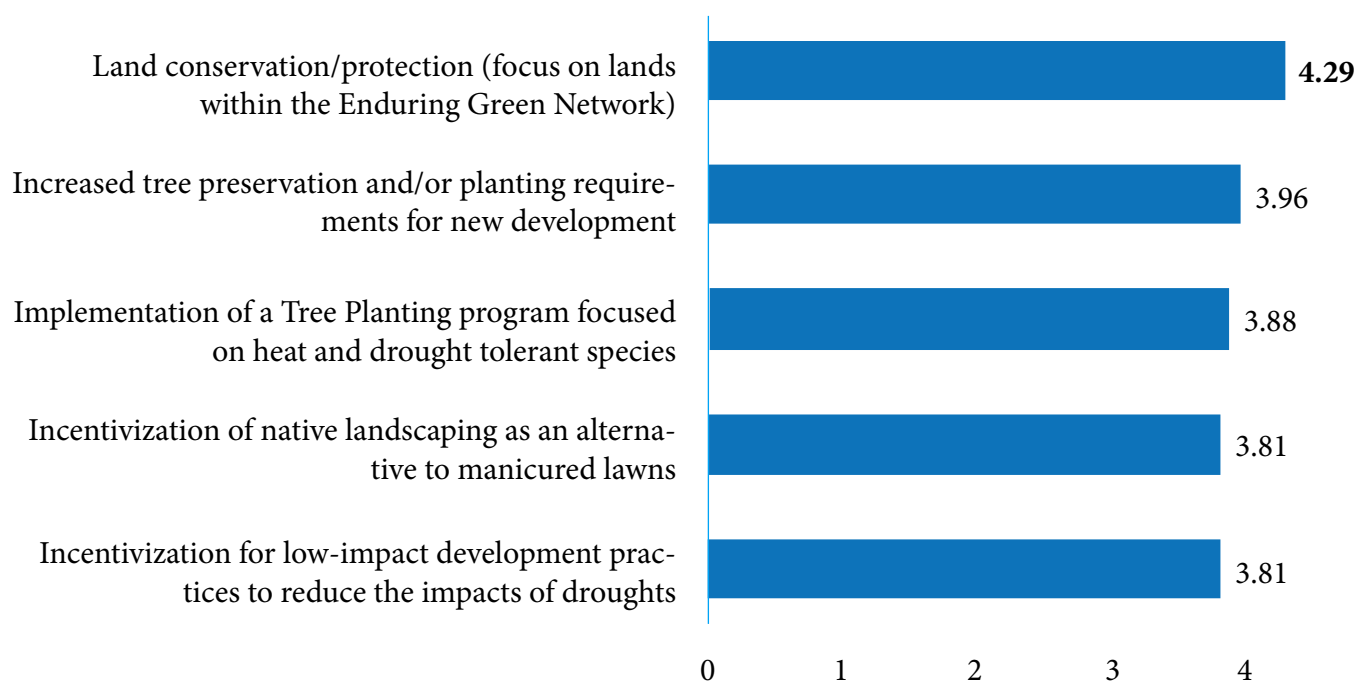


Figure 9: Results for the Strategies needed to achieve Recreation and Tourism Protection

IDENTIFIED STRATEGIES

The key stakeholders from all 5 categories were polled after each meeting to identify the most significant proposed strategies that could better prepare Fayetteville for extreme weather conditions and ensure economic, natural, physical, health, and social resiliency within the community. The major recurring strategies were:

1. IMPROVEMENT OF LAND CONSERVATION AND PROTECTION PRACTICES

There are a number of programs, projects, and partnerships which the CoF and the UA could use to improve land conservation and protection, such as:

- Identify Best Management Practices for areas affected by the extreme weather scenarios
- Propose specific policies and solutions regarding lands within the Enduring Green Network, Beaver Watershed areas, and riparian lands near water bodies
 - Increased tree preservation and/or planting requirements to increase the tree canopy
- Improved zoning and development regulations
- Support NWA Land Trust (financial, policy, advocacy)
- Campaign for personal contribution
 - Incentivizing native landscaping as an alternative to manicured lawns through certifications and/or awards

2. IMPLEMENTATION OF STORMWATER MANAGEMENT PRACTICES

Stormwater management is imperative to a resilient community. The CoF, UA, and community members are tasked with protecting the area's water supply, land, agriculture, natural habitats, and general quality of life for all residents. This strategy could be achieved by:

- Installing Low Impact Development features which encourage stormwater capture in high risk flood areas to reduce flooding impacts and recharge the groundwater supply
 - Adding features both in new development and when retrofitting existing development
- Developing Heat Island Cooling techniques and policies meant to prevent the Urban Heat Island Effect in identified affected areas
 - Communicate with relevant groups such as the Beaver Watershed Alliance, the Watershed Conservation Resource Center, and the Illinois River Watershed Partnership





3. DEVELOPMENT OF A WILDFIRE PREVENTION PLAN AND BURN BAN COMMUNICATION STRATEGY

Increasing annual temperatures and extreme drought pose threats to residents and their land, natural areas, and municipal assets during periods of Burn Bans. A Wildfire Prevention Plan and communication strategy could be implemented by:

- Utilizing existing “Code Red” systems to ensure all residents are notified during drought event
- Amplify community engagement and education
- Encourage prescribed fires on large publicly held lands to reduce future wildfire risk

4. IMPROVEMENT OF ENERGY SAVINGS PROGRAMS

Increasing temperatures and extreme drought will cause industries and the public to use more resources, such as energy. This strategy could be implemented by:

- Developing and deploying renewable energy generation facilities to reduce demand on the electrical grid
- Creating incentives to use less energy
 - Reducing per capita vehicle miles traveled
 - Waste diversion
- Educating the public on continued efforts and improvements to the Climate and Energy sector in the CoF, such as the Energy Action Plan (2017)

CONCLUSIONS

Community Resilience is about more than a community simply surviving disaster and change. A truly resilient community will not only meet these challenges, but grow stronger and more united because of them, all while maintaining its unique cultural identity. Communication of the importance of sustainable design and living enhances the resilient well-being of communities. Knowledge and information regarding community resiliency is imperative to the future success of students, the City of Fayetteville, and community members.

Education about sustainable practices and development of programs and procedures meant to better protect our community in the domains of economic, natural, physical, health, and social resiliency are necessary to ensure our city grows stronger as annual temperatures increase and drought ensues. After conducting the stakeholder meetings and analyzing the resiliency assessment survey results, there are strategies available and steps to take. Collaboration between the University of Arkansas, the City of Fayetteville, and community groups will allow change to occur beyond the realm of municipal government. The investment in our community is aimed to reduce the effects of our identified vulnerabilities and better enhance our strengths.

The most significant outcome of conducting this assessment was bringing together key decision makers and actuators within our community and introducing them to the concept of community resilience. Fayetteville's community is already full of people dedicated to positive change and boasts a progressive and innovative culture. It is ready to move towards a resilience mindset. This assessment educated and engaged key members within the community about resilience so that they can now advocate for thoughtful solutions.

LOOKING FORWARD

INITIAL OPPORTUNITIES FOR COMMUNITY RESILIENCE

As the City of Fayetteville takes preliminary steps to enhance community resiliency, it is important to identify measurable Key Performance Indicators (KPIs). Once these KPIs are identified, initiatives to measure and track each indicator can take place. With respect to the extreme weather the City of Fayetteville may face, indicators such as electricity consumption, greenhouse gas emissions, and cost of utilities are excellent metrics to base future policy and resiliency planning from. In addition to city-wide KPIs, the University of Arkansas has a unique opportunity to join the resiliency campaign by identifying and measuring KPIs such as water used per student or per building, the amount of food waste from each dining hall, or the amount of electricity used per dorm.

The City of Fayetteville and the University of Arkansas have ample opportunities to learn from and interpret these KPIs, and later use them to develop applicable community resiliency strategies alongside the key stakeholders. The concept of creating community resilience is an iterative process. This process must follow a Continuous Improvement Framework which works to define, measure, and implement the strategies of community resilience. Resiliency has been defined for the key stakeholders, and should now be communicated to the community. The priorities of the City of Fayetteville and the University of Arkansas can be defined, as well as the metrics that support these priorities. The metrics should be measured, and community resilience strategies should be developed. Finally, these resiliency strategies should be implemented, and further iterated to adapt to changing scenarios.

2018 FAYETTEVILLE CLIMATE RESILIENCE ASSESSMENT

APPENDICES



Table 1. Historic Extreme Climate Data for Fayetteville, Arkansas (ADOPTED) (Source One – NOAA, Source Two – The Weather Channel)

Climate data for Fayetteville, Arkansas (1981–2010 normal, extremes 1892-present)													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °F (°C)	76 (24)	86 (30)	96 (36)	96 (36)	95 (35)	104 (40)	111 (44)	109 (43)	105 (41)	96 (36)	90 (32)	78 (26)	111 (44)
Average high °F (°C)	46.4 (8)	51.0 (10.6)	59.2 (15.1)	68.8 (20.4)	75.9 (24.4)	83.6 (28.7)	88.8 (31.6)	89.2 (31.8)	81.2 (27.3)	70.4 (21.3)	59.0 (15)	48.4 (9.1)	68.6 (20.3)
Daily mean °F (°C)	36.3 (2.4)	40.4 (4.7)	48.5 (9.2)	57.8 (14.3)	65.8 (18.8)	74.1 (23.4)	79.0 (26.1)	78.5 (25.8)	70.2 (21.2)	58.9 (14.9)	48.6 (9.2)	38.6 (3.7)	58.2 (14.6)
Average low °F (°C)	26.3 (-3.2)	29.7 (-1.3)	37.8 (3.2)	46.9 (8.3)	55.8 (13.2)	64.6 (18.1)	69.2 (20.7)	67.8 (19.9)	59.2 (15.1)	47.4 (8.6)	38.2 (3.4)	28.8 (-1.8)	47.7 (8.7)
Record low °F (°C)	-23 (-31)	-24 (-31)	-11 (-24)	18 (-8)	28 (-2)	41 (5)	48 (9)	44 (7)	29 (-2)	17 (-8)	5 (-15)	-12 (-24)	-24 (-31)
Average precipitation inches (mm)	2.55 (64.8)	2.39 (60.7)	4.02 (102.1)	4.30 (109.2)	5.20 (132.1)	4.77 (121.2)	3.22 (81.8)	3.05 (77.5)	4.56 (115.8)	4.10 (104.1)	4.33 (110)	3.04 (77.2)	45.53 (1,156.5)
Average snowfall inches (cm)	2.8 (7.1)	2.6 (6.6)	1.1 (2.8)	0.1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.6 (1.5)	1.4 (3.6)	8.6 (21.8)
Average precipitation days (≥ 0.01 in)	6.5	7.6	9.1	9.2	12.4	9.4	7.5	7.0	8.5	8.5	7.5	7.5	105.4
Average snowy days (≥ 0.1 in)	0.8	1.1	0.1	0	0	0	0	0	0	0	0.1	0.4	2.6

The Weather Channel. (2019). Fayetteville, AR Monthly Weather. Retrieved from:
<https://weather.com/weather/monthly/l/USAR0189:1:US>

APPENDIX B: STAKEHOLDER MEETING ATTENDEES

Table 2. Stakeholder Meeting Information

Domain	Location	Date	Attendees from UofA	Attendees from CoF	Attendees from Community Stakeholders
Natural	Fayetteville City Hall	September 20, 2017	3	3	3
Physical	Fayetteville City Hall	September 26, 2017	5	7	5
Human	Fayetteville City Hall	September 27, 2017	2	4	1
Social	Fayetteville City Hall	October 6, 2017	8	8	
Economic	Fayetteville City Hall	October 12, 2017	8	8	

Table 3. List of attendees at the meeting to discuss natural climate resilience.

Ecosystem Vitality

Rep	Name	Title	Email
UA	Colin Massey	DEA Ag/Water Quality, Washington County Cooperative Extension Service	cmassey@uaex.edu
UA	Eric Boles	Director, Office for Sustainability	eboles@uark.edu
UA	Sarah Lewis	Sustainability Consortium	sarah.lewis@sustainabilityconsortium.org
CoF	Peter Nierengarten	City of Fayetteville Director of Sustainability	pnierengarten@fayetteville-ar.gov
CoF	Leif Olson	City of Fayetteville	lolson@fayetteville-ar.gov
CoF	Rachael Schattner	City of Fayetteville	rschattner@fayetteville-ar.gov
3 rd	John Pennington	Executive Director, Beaver Watershed Alliance	John@BeaverWatershedAlliance.org
3 rd	Terri Lane	Executive Director, Northwest Arkansas Land Trust	tlane@nwalandtrust.org

3 rd	Sandi Formica	Executive Director, Watershed Conservation Resource Center	formica@watershedconservation.org
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Table 4. List of attendees at the meeting to discuss physical climate resilience.

Physical/Infrastructure

Rep	Name	Title	Email
UA	Eric Boles	Director, UA Office for Sustainability	eboles@uark.edu
UA	Samuel Lahodny	UA Office for Sustainability	sslahodn@uark.edu
UA	John Doerpinghaus	UA Industrial Engineering Masters Student	jdoerpin@uark.edu
UA	Sara Gosman	Law Professor	sgosman@uark.edu
UA	Peter MacKeith	Dean of Architecture	mackeith@uark.edu
CoF	Peter Nierengarten	City of Fayetteville Director of Sustainability	pnierengarten@fayetteville-ar.gov
CoF	Ken Eastin	City of Fayetteville	keastin@fayetteville-ar.gov
CoF	Ted Jack	City of Fayetteville Parks and Recreation	tjack@fayetteville-ar.gov
CoF	Leif Olson	City of Fayetteville	lolson@fayetteville-ar.gov
CoF	Chris Brown	City Engineer	cbrown@fayetteville-ar.gov
CoF	Terry Gulley	Transportation Director	tgulley@fayetteville-ar.gov
CoF	Tim Nyander	Fayetteville Utilities Director	tnyander@fayetteville-ar.gov
3 rd	Pam Nelson	Program Assistant, NWA Land Trust	pnelson@nwalandtrust.org
3 rd	Jeff Milford		jamilford@aep.com
3 rd	Rob Smith		robsmith@nwacouncil.org
3 rd	Mark Mobley	Swepeco representative	mcmobley@aep.com
3 rd	Kris Williams	Ozarks Electric representative	kwilliams@ozarksecc.com

Table 6. List of attendees at the meeting to discuss human health climate resilience.

Human Health

Rep	Name	Title	Email
UA	Eric Boles	Director, UA Office for Sustainability	eboles@uark.edu
UA	Shaina Hayutin	UREC Wellness	sehayuti@uark.edu
CoF	Peter Nierengarten	City of Fayetteville Director of Sustainability	pnierengarten@fayetteville-ar.gov
CoF	Chief David Dayringer	Fire Chief	ddayringer@fayetteville-ar.gov
CoF	Gabriel Gutierrez	CoF Sustainability Dept. Intern	Gg012@uark.edu

CoF	Leif Olson	City of Fayetteville	lolson@fayetteville-ar.gov
3 rd	Linda Thompson	CPS, Arkansas Dept. of Health	linda.thomposn2@arkansas.gov

Table 5. List of attendees at the meeting to discuss social climate resilience.

Social Dynamics

Rep	Name	Title	Email
UA	Eric Boles	Director, UA Office for Sustainability	eboles@uark.edu
UA	Lynne Williams Bell	Student Affairs	lynnew@uark.edu
UA	Rogelio Garcia Contreras	UA Walton College	rgarciacontreras@walton.uark.edu
CoF	Yolanda Fields	Fayetteville Community Services Manager	yfields@fayetteville-ar.gov
CoF	Dede Peters	City of Fayetteville Communications	dpeters@fayetteville-ar.gov
CoF	Leif Olson	City of Fayetteville	lolson@fayetteville-ar.gov
CoF	Peter Niengarten	City of Fayetteville Director of Sustainability	pnierengarten@fayetteville-ar.gov

Table 7. List of attendees at the meeting to discuss economic climate resilience.

Economic Well-Being

Rep	Name	Title	Email
UA	Eric Boles	Director, UA Office for Sustainability	eboles@uark.edu
UA	Jon Johnson	Sustainability Consortium	JJohnson@walton.uark.edu
UA	Vickie Ferguson	UA Foundation	vickie@uafound.org
UA	Kent Kovacs	UA Professor of Agricultural Economics & Agribusiness	kkovacs@uark.edu
CoF	Peter Nierengarten	City of Fayetteville Director of Sustainability	pnierengarten@fayetteville-ar.gov
CoF	Leif Olson	City of Fayetteville	lolson@fayetteville-ar.gov
CoF	Devin Howland	Economic Vitality Director	dhowland@fayetteville-ar.gov
CoF	Paul Becker	CFO	pbecker@fayetteville-ar.gov
CoF	Andrew Garner	City of Fayetteville	agarner@fayetteville-ar.gov
CoF	Garner Stoll	City of Fayetteville	gstoll@fayetteville-ar.gov
3 rd	Ammen Jordan	Citizen	ammen.jordan@gmail.com
3 rd	Katherine Teague	CEA Agriculture, Washington County Extension Service	kteague@uaex.edu
3 rd	Jeff Amerine	Start Up Junkie	jeff@startupjunkieconsulting.com